THE ADMINISTRATION OF NITROUS OXIDE & OXYGEN FOR DENTAL OPERATIONS.

Frederic W. Hewitt,
M.D.

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FOR

DENTAL OPERATIONS

BY

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TO

THOSE OF THE PAST AND PRESENT

SURGEONS AND ASSISTANT SURGEONS

OF THE

DENTAL HOSPITAL OF LONDON

WITH WHOM I HAVE BEEN ASSOCIATED WHILST MAKING

THE OBSERVATIONS HEREIN CONTAINED,

I VENTURE TO

DEDICATE

THIS LITTLE BOOK,

IN GRATEFUL RECOGNITION OF THE PATIENCE AND COURTESY

WHICH THEY HAVE INVARIABLY DISPLAYED DURING

THE PROGRESS OF THE INVESTIGATION.

PREFACE.

ELEVEN years have elapsed since I commenced working at this subject. The first eight years were mainly devoted to conducting preliminary experimental administrations of various mixtures of nitrous oxide and oxygen, and to devising and perfecting apparatus. The last three years have been occupied in ascertaining the precise influences exerted by this or that percentage of air or of oxygen upon the usual asphyxial phenomena of pure nitrous oxide.

My original intention was to incorporate in one volume the results of both parts of the research, but I have since decided to adopt a different course, and to first place in the hands of the medical and dental professions this small treatise dealing more particularly with the practical aspects of the subject, and subsequently to bring forward the large mass of evidence which I now possess concerning

the physiological effects of different mixtures of nitrous oxide with air or oxygen.

Safe and thoroughly efficient anæsthesia for dental operations is of such importance that it behoves every dental practitioner to carefully consider whether he should not abandon the prevalent but comparatively crude and unscientific method of producing insensibility from nitrous oxide, and avail himself of the new system.

It is true that there are at present some difficulties in the way of this advance, but it is to be hoped that they may soon be surmounted. The principal of these undoubtedly is the difficulty of obtaining proficient anæsthetists. Increased facilities, however, are now being afforded at most hospitals for acquiring experience in administering anæsthetics, so that there is every reason to believe that, in course of time, there will not be that dearth, which now exists, of medical men capable of administering nitrous oxide in dental practice.

Moreover, I hope to see the day when the immense amount of clinical material which is now being wasted, so to speak, at our dental hospitals, will be utilised, not only for the systematic instruction of dental students who are intending to qualify in medicine, but for that of extraneous students and practitioners.

In this way it would be possible to efficiently train medical men in dental anæsthetics, and to keep the dental profession supplied, as it were, with proficient anæsthetists throughout the country.

FREDERIC W. HEWITT.

10, George Street,
Hanover Square, W.
May, 1897.

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CHAPTER I.

INTRODUCTION.

In reviewing the past history of nitrous oxide as an anæsthetic one cannot help being struck by the singular vicissitudes which this agent has experienced. That a quarter of a century should have passed between its discovery by **Priestley** and the recognition of its pain-relieving properties by **Davy** is sufficiently remarkable. But more curious still is the fact that nearly double this length of time elapsed between Davy's observations and the first administration of the gas for a surgical operation. It was during this latter interval that nitrous oxide received the name of "laughing gas" from the power it possessed, when small quan-

tities were breathed backwards and forwards, of producing hilarious excitement.

In December, 1844, Dr. **Colton,** "an itinerant lecturer on chemistry" (to use a description given of him by one of his own countrymen),[1] demonstrated these effects at Hartford, Conn., U.S.A. At this entertainment **Horace Wells,** a dentist, was present, and noticing that one of the audience who had inhaled the gas had unconsciously bruised himself whilst under its influence, he shrewdly suspected that the so-called "laughing gas" might prove to be of valuable service in dentistry. This brilliant idea was quickly put to the test: Colton administered the gas to Wells: and a friend of the latter extracted a tooth during the anæsthesia thus produced. This administration of nitrous oxide, although conducted in the crudest manner, will ever deservedly remain a memorable one; for it laid the foundation stone, so to speak, of our present system of surgical anæsthesia.

The realisation of the hopes which Wells had entertained was so complete that he naturally enough looked forward to an uninterrupted and glorious reign for the new anæsthetic whose services in surgery he had been the first to requisition. His first public demonstration, however, unfortunately proved a fiasco: and this circumstance, coupled with the fact that

intense interest soon became universally felt at the discovery, by Morton, of the anæsthetic properties of ether, rapidly placed nitrous oxide again upon the shelf, where it remained, more or less forgotten, for a further term of nearly twenty years. A little reflection will at once show that Wells's anæsthetic was heavily handicapped in its struggle for existence. Its physical characters were against it. Being gaseous at ordinary temperatures and pressures, it was, as compared to its liquid rivals, ether and chloroform, more or less unmanageable. It was, moreover, a difficult matter to obtain the gas in a state of purity, and in sufficiently large quantities for administration.

But the chief cause of the discredit into which the gas fell was the want of knowledge which necessarily prevailed as to the principles which should be followed in its administration. The methods employed by Wells and his followers were such as to render success or failure merely a matter of chance. The administration was very simply conducted. Some of the gas was placed in a bag or bladder to which was attached a tube, and the patient breathed backwards and forwards. The results which followed were necessarily exceedingly irregular, as the chronicled accounts of Wells's demonstration and of subsequent attempts to produce anæsthesia amply testify. In addition to the

fact that much of the nitrous oxide which was employed itself contained air, it must be remembered that the re-breathing of a small quantity of the gas necessarily led to its dilution by the air already present in the respiratory passages. The early administrations of nitrous oxide were, indeed, administrations of nitrous oxide mixed with considerable proportions of nitrogen, oxygen, and carbonic acid gas, to say nothing of the impurities other than air which may or may not have been present in the anæsthetic employed for inhalation. Loud and prolonged laughter, crying, shouting, praying, semi-maniacal excitement, and many grotesque and amusing phenomena manifested themselves—phenomena which we now know to have been produced by the too free dilution of the gas with the oxygen of atmospheric air. In some of the cases in which teeth were removed no pain was experienced; in others the pain was only partly abrogated; in many the pain was felt with the usual or even with more than the usual acuteness.

It was not until 1863 that nitrous oxide again began to emerge from the seclusion into which it had been forced by reverses of fortune. In this year a dentist named **Smith,** of New Haven, Conn., took upon himself the responsibility of submitting one of his patients to its

influence, and the results were this time so satisfactory that Colton, who was again the administrator, forthwith proceeded to New York where, with several influential dentists, he established an association bearing his name, for the painless extraction of teeth. Writing in March, 1881, Dr. Colton stated that no less than 121,709 administrations of nitrous oxide had been conducted by the Colton Dental Association since July, 1863, when the Association was founded, and that no accident had occurred.

The news of Colton's success soon crossed the Atlantic, and in January, 1864, Mr. **Rymer,** a London dentist, reported[2] some experimental administrations of nitrous oxide which he had undertaken at the National Dental Hospital. In these experiments either a bladder or an india-rubber bag was used, and the patient breathed the gas backwards and forwards through a tube of large calibre. According to the interesting paper published by Mr. Rymer, the results were very satisfactory.

So far as I am able to ascertain, the first apparatus which possessed valves to prevent re-breathing, was that used by Dr. **Evans** of Paris, at a very successful demonstration which he gave at the Dental Hospital of London in 1868. The introduction of this improved

method of administration was quickly followed by the manufacture of liquefied nitrous oxide; and, for the first time since Horace Wells's experiment, nitrous oxide began to occupy an unassailable position amongst its rivals in the great field of therapeutics. **Clover,** whose ingenuity in devising other anæsthetic apparatus had already become conspicuous, quickly improved upon the still rough nitrous oxide inhalers, and laid down rules to be observed in administration.

The complications which had attended the earlier administrations of nitrous oxide, if such they can be called, had been due to the presence of atmospheric air in too large quantities; those which now began to appear, with the more perfected apparatus, were of an exactly opposite nature. The recognition of the effects produced by the admission of air now led to its most stringent exclusion. The pendulum, in fact, began to swing just as far in this direction as it had swung in the other. It was thought that because air produced excitement it should necessarily be wholly excluded—a view which subsequent experience has taught us to modify. With this new system of administration, it soon became clear that a more or less continuous inhalation was impossible. Given that the gas was mixed with no air or oxygen, that no re-breathing was possible, and

that the inhaling apparatus fitted and worked accurately, nitrous oxide could not be given for more than a very brief space of time. After the inhalation had lasted a minute or so, certain phenomena arose which necessitated the withdrawal of the anæsthetic and the admission of air. It therefore became clear that nitrous oxide was *par excellence* the anæsthetic for very brief operations. Prolonged operations could only be accomplished under its influence, and these not very satisfactorily, by intermittently allowing air to be respired.

The next step in the development of nitrous oxide anæsthesia was taken by the late Prof. **Paul Bert,** whilst engaged with his researches upon barometric pressure. In a communication which he made to the Société de Biologie, on Feb. 9, 1878, he stated[3] that he found the effects of toxic gases upon living organisms to be dependent upon their tension when breathed. Nitrous oxide was a gas which, at the ordinary atmospheric pressure, would only produce anæsthesia when administered *pure*, *i.e.*, free from air. Unfortunately, however, in administering nitrous oxide free from all air, asphyxial phenomena soon became developed. But if a mixture of one half nitrous oxide and one half air were administered in a closed chamber in which the ordinary barometric pressure could be doubled, then the blood

would receive just as much nitrous oxide as when the gas was administered pure at ordinary pressures, and just as much air as would be breathed under natural circumstances. In this way prolonged anæsthesia would be possible and asphyxia would be avoided. As we shall subsequently see, Bert's original proposition as to the necessity of employing perfectly pure nitrous oxide for the production of anæsthesia was not true. His idea was nevertheless as brilliant as it was ingenious. Bert soon saw that by employing oxygen instead of air it would be unnecessary to dilute the nitrous oxide to anything like the extent above indicated, so that a comparatively small increase in barometric pressure would be needed.

On the 11th May, 1878, Bert stated[4] that he had successfully anæsthetised a dog with a mixture of 80 per cent. of nitrous oxide and 20 per cent. of oxygen, under an additional barometric pressure of 20 cm. There was no excitement, and no material disturbance of the normal functions of respiration and circulation. The anæsthesia was everything that could be desired.

On the 13th of July following he announced[5] that, by his method, he had kept a dog anæsthetised, and free from asphyxial symptoms, for half an hour; that a manometer

placed in an artery had not shown any perceptible variations in tension; that the blood pressure had been raised by irritating exposed nerves; that irritation of the pheripheral end of the vagus had stopped the heart; and that irritation of its central end had stopped the respiration.

On Nov. 11th of the same year Bert made[6] a preliminary report of his results to the Académie des Sciences.

On Feb. 15th, 1879, he announced[7] to the Société de Biologie that two days previously his method of producing anæsthesia had been for the first time tried upon the human subject. A large air-tight metal chamber in which, by means of pumps, the barometric pressure could be raised, had been employed, and a mixture of 85 per cent. of nitrous oxide and 15 per cent. of oxygen had been administered from a bag by means of a face-piece with two valves, the barometric pressure in the chamber being 92 cm. (= an increase of 17 cm.). The operation, which was the avulsion of a toe nail, had been a complete success. There had been no pain, very little movement, no excitement, a quiet pulse, and no loss of colour. The tension of the nitrous oxide had been $85 \times \frac{92}{75} = 104$; and that of the oxygen $15 \times \frac{92}{75} = 18{\cdot}4$; in other words, that of the nitrous oxide had been a little higher than

when the pure gas was given at ordinary pressures, and that of the oxygen a little lower than that of the air (20·9). Incidentally Bert remarked that such a mixture as that which he employed would not produce anæsthesia at ordinary pressures—a point to which I shall have to refer later on.

Bert's next communication[8] is dated Feb. 21st, 1880. On this occasion he advocated a total barometric pressure of 89·5 cm. and a mixture of similar proportions to those before described.

The almost ideal type of anæsthesia produced by Bert's method attracted such attention, especially on the Continent, that attempts were soon made to obtain similar results without the employment of the costly and cumbrous apparatus which Bert had devised. Thus, **Klikowitsch**,[9] **Winckel**,[10] **Döderlein,** and **Zweifel** employed a mixture of 80 per cent. of nitrous oxide and 20 per cent. of oxygen in obstetric practice, administering the gases as nitrous oxide itself is customarily administered. In most of the cases in which records are available an analgesic effect seems only to have been produced, the patient's consciousness having remained more or less intact whilst her pains were relieved.

The first systematic application of Bert's method to dental practice was made by Dr.

C. **Martin** of Lyons, whose monographs[11] upon the subject are of great interest. Having provided himself with an air-tight metal chamber, and with the necessary machinery for raising the barometric pressure, he proceeded to carry out Bert's directions. He found, however, that by carrying them out to the letter he met with considerable excitement, and a "disturbed sleep, barely anæsthetic." The results were, in fact, inferior to those obtainable with nitrous oxide as ordinarily given. He therefore tried an increase of barometric pressure, raising it to 95 cm., 100 cm., and even to 125 cm., but without success. He next tried 12 per cent. of oxygen instead of 15 per cent., as recommended by Bert. Anæsthesia now more rapidly ensued; there was less excitement; there was no cyanosis; and recovery was satisfactory. These results were obtained with a pressure of 105 cm. He next raised the pressure to 110 cm., and for the first time he obtained results comparable to those described by Bert. When any excitement began to manifest itself an increase in the barometric pressure quickly arrested it. Martin found it best to wait from 2 to 3 minutes before operating, and in the event of a long anæsthesia being necessary he administered the mixture for 4 or even 5 minutes before beginning the extraction. It is interest-

ing that he found that if the pressure were only 100 cm., or 105 cm., the patient recovered more quickly than with a pressure of 115 or 120 cm. After-nausea was more frequent in the prolonged administrations than in the others.

I have elsewhere[12] described an interesting experiment which M. Martin made upon a dog. He kept the animal breathing a mixture of 85 per cent. of nitrous oxide and 15 per cent. of oxygen under a pressure of from 110 to 120 cm., for three consecutive days, without any untoward effects during or after the insensibility. Nothing could more forcibly demonstrate the harmlessness of the mixture than such an experiment.

On April 30th, 1883, Bert read his final paper on the subject.[13] Having reviewed his previous work, he stated that he had been endeavouring to produce prolonged nitrous oxide anæsthesia without the employment of increased atmospheric pressure, and that he had been successful in the case of the lower animals. He regarded the alternate administration of nitrous oxide and air as objectionable. He first tried administering nitrous oxide and oxygen alternately; but the rapid elimination of the former gas in the presence of the latter led to a too sudden recovery. He next administered, alternately, pure nitrous oxide and a

mixture of nitrous oxide and oxygen similar to that which he used in his pressure cases. He was thus able to keep a dog unconscious for half an hour. At the time of his paper he had not tried this method in human beings, nor can I find any record of his having subsequently done so. He urged surgeons, however, to give it a trial, and stated that he intended to make further experiments as to the best percentages for the mixture.

Dr. **Hillischer** of Vienna, a well-known dentist, was the first to successfully employ nitrous oxide and oxygen, at ordinary atmospheric pressures, in dental surgery. His first paper appeared[14] in 1886; his second[15] and third[16] in 1887; and his fourth[17] and fifth[18] in 1890. He suggested that the gaseous mixture should be termed "Schlafgas" from the sleep-like state into which patients pass under its influence. Dr. Hillischer has administered nitrous oxide and oxygen in upwards of 15,000 cases; and the facts which he has brought forward fully justify him in entertaining such high opinions of the mixture he employs. In his earlier cases he used gasometers, but in latter years he has employed a regulating apparatus by which the proportion of oxygen can be increased or diminished during the administration. He very properly directs attention to the necessity of this plan; for patients

vary very considerably in the percentage of oxygen needed to secure a good type of anæsthesia.

Dr. Hillischer states that he has administered "Schlafgas" to patients of all ages; to those suffering from advanced affections of the heart; to those with diseases of the lungs; and to the subjects of epilepsy and other nervous diseases. He further states that he looks upon the gaseous mixture as absolutely without contra-indication—that he administers it to every patient irrespective of any morbid state which may be present. He admits that far more experience is needed in administering "Schlafgas" than in giving any other anæsthetic with which we are acquainted; and there can be no doubt that, here again, he is perfectly correct. As to the percentage of oxygen, he finds it best, in most cases, to commence with 10 per cent. and to gradually increase this to 15 or even 20 per cent. With regard to alcoholic subjects and others who are rebellious to the influence of nitrous oxide with 10 per cent. of oxygen, he reduces the proportion to 5 per cent. or even less. On the other hand, if he finds that the breathing becomes laboured, or that the features assume a cyanotic appearance, he increases the percentage of oxygen.

Dr. **Witzel,** of Essen-on-the-Ruhr, has also administered nitrous oxide and oxygen for a

large number of dental operations, and in some interesting lectures which he published[19] in 1889, he strongly urges the advantages of the mixture and the correctness of Hillischer's views.

Dr. H. C. **Wood,**[20] of Philadelphia, has been unable to satisfy himself as to the anæsthetic effects of nitrous oxide and oxygen in the lower animals. He states, for example, that in the dog, nitrous oxide mixed with 8 per cent. of oxygen indefinitely postpones anæsthesia. The tests upon which he relies, in estimating anæsthesia, are however, open to considerable criticism. But, apart from this, we now possess such a mass of incontrovertible clinical evidence that in the human being safe and thoroughly satisfactory anæsthesia can be produced with nitrous oxide and oxygen, that it is difficult to understand the views put forward by this eminent authority.

In 1886 I commenced, at the Dental Hospital of London, a series of experimental administrations of nitrous oxide and oxygen, at ordinary atmospheric pressures, with the object of ascertaining the best method for general use. It would serve no useful purpose to describe, on the present occasion, the numerous procedures which were adopted. No less than 13 distinct plans were tried, each of which necessitated a different form of apparatus.

Those who are specially interested in the matter, however, will find, in another publication,[21] a full description of the stages by which I arrived at the apparatus which I brought out in 1894—the apparatus which is fully described in the following chapter. That it should have taken so long to devise a workable method may appear remarkable. But the fact is, that, as the experiments proceeded, so it became more and more clear that attention had to be paid to the minutest possible details.

One of the first points that became obvious was that sudden transitions in the composition of the gases breathed were to be avoided. For example, no good results could be obtained by suddenly changing from ordinary nitrous oxide to a mixture containing a considerable percentage of oxygen; or from one containing a small to one containing a large percentage; or *vice versâ*.

I then endeavoured to ascertain whether any definite percentage of oxygen with nitrous oxide would answer in every case. I found that in most cases a mixture containing $12\frac{3}{4}$ per cent. of oxygen answered admirably. By its use all asphyxial phenomena were avoided; there was no stertor, jactitation, or lividity; breathing continued without the slightest embarrassment; the natural colour was preserved; and in most cases the anæsthesia

was perfect and tranquil. In a certain number of cases, however, excitement and screaming arose, and it was necessary to let some pure nitrous oxide into the mixture in order to terminate the case satisfactorily. My results with this mixture were published in the *Lancet*.[22]

The next point that proved to be of importance was the necessity of absolutely excluding air during the inhalation. There can be no doubt that in administering nitrous oxide in the usual manner a small quantity of air is very likely to gain access to the lungs, either under the face-piece, or at the expiratory valve. If nitrous oxide, with or without oxygen, be administered in such a way that the inhaling bag is kept distended, it is obvious that no such admixture of air can occur. I was at a loss for some time to account for the better results obtained in administering nitrous oxide and oxygen (the oxygen being present to the extent of 12½ or 10 per cent.) when the gases issued from the gasometer under slight pressure; but there is little doubt that the explanation given is the true one, and that when the gases were given with a half-distended bag small quantities of air gained access and disturbed the anæsthesia. The admixture of a small quantity of air during an ordinary administration of nitrous

oxide is, if anything, an advantage, at all events in most cases; but it is not so with nitrous oxide and oxygen.

I next came to the conclusion that 10 per cent. of oxygen was preferable to 12½ per cent., and when this mixture was administered from a distended bag very good results occurred in most cases.

It soon became clear, however, that there was no definite percentage of oxygen which in every case would prevent all traces of asphyxia, and yet would in no way interfere with anæsthesia. Patients varied too widely for the employment of any method of this nature. It was obviously necessary to have control over the percentage of oxygen, so that it could be increased or diminished during the administration, in accordance with the needs of the case. I therefore tried various kinds of regulating apparatus which I devised. I also tried Hillischer's apparatus; but the results which I obtained with it were not satisfactory. Its chief fault seemed to be that it did not allow of fine enough adjustment in its oxygen inlet. The channels through it, moreover, were of very small calibre, the bags were too far from the mouthpiece, and the valves did not work with that perfect freedom which is essential.

The first apparatus with which I obtained reliable results was described by me before

the Odontological Society in 1892;[21] and I demonstrated[23] the results which could be obtained with it, at the meeting of the British Dental Association at Manchester in the same year. I need not refer to its mechanism here, as the apparatus was similar in its main principles to that which is fully described in the following chapter. There were two separate bags; one for nitrous oxide, the other for oxygen. The oxygen was admitted to the nitrous oxide through thirteen small circular holes, any number of which could be opened. I found four flap valves necessary: two prevented re-breathing, and two prevented any diffusion of the gases before they were mixed. The expiratory valve was found to be much more efficient in preventing air gaining access during its closure when a chimney was fitted to its orifice. If the valve was not thus guarded, a small quantity of atmospheric air was very liable to be drawn in during its closure.

The apparatus which I now use was brought before the notice of the British Dental Association at Newcastle-on-Tyne in 1894.[24] I propose, however, to fully describe it again here, and when this has been done, to consider in detail the effects which it produces. By this plan we shall, I think, be in a favourable position to realise the immense advantages of obtaining an anæsthesia which, when properly

established, may be regarded as absolutely safe, and certainly far more satisfactory, from the operator's point of view, than that which we have been accustomed to meet with when employing nitrous oxide gas in the usual manner.

CHAPTER II.

APPARATUS.

1. Gasometer Methods.

Whilst it is true, as already stated, that there is no definite percentage of oxygen which will answer satisfactorily in every case, and that, to obtain the best results, a regulating apparatus is essential, it is equally true that **a continuous administration, by means of a gasometer, of certain known mixtures of the two gases,** will produce better results than can be obtained by nitrous oxide alone.

The question hence arises: What percentage of oxygen should be used in gasometer administrations?

In reply to this question I may say that, during the course of the investigation referred to in the Preface, I have found that of all the mixtures which I have tried for continuous administration, the best results have been secured with those containing **5, 6, 7 or 8 per cent.** of oxygen, according to the type of

patient. I hope soon to be in a position to speak more definitely upon this interesting point, for much misconception at present exists as to the effects produced by different percentages of oxygen. Without going further into detail here, I may say, however, that *if the apparatus works accurately, and air is absolutely excluded*, percentages of oxygen above those indicated, are, as a general rule unnecessary. That cases arise in which higher or lower percentages should be given is beyond doubt; but such cases can only be successfully met when a regulating apparatus is used. Given that no such apparatus is at hand, the percentages to which I have referred are certainly preferable to others, and with these percentages good results may be attained in most, if not in all cases. I have found that the chief objection to higher percentages is the liability to excitement. It must be remembered, too, that with 5 per cent. of oxygen one is very near the asphyxial borderland. Indeed, when administering a mixture containing this percentage of oxygen, cases will occasionally be met with in which minor degrees of stertor, jactitation, and lividity, are present. Such cases would necessarily follow a different and more satisfactory course were a regulating apparatus employed.

A word of caution is perhaps necessary with

regard to keeping nitrous oxide and oxygen together, in gasometers, for any length of time. Hillischer states that traces of the higher oxides of nitrogen were detected, at the end of a week, in a mixture which had been kept in Ludwig's laboratory. The two gases should therefore be mixed as required.

2. The Author's Regulating Apparatus.

Before describing this in detail it may be well to briefly enumerate the various **requirements** which must be fulfilled by any regulating apparatus for the administration of nitrous oxide and oxygen. They are as follows :—

(1) There must be a plentiful supply of the two gases from easily and quietly working cylinders :

(2) The bags into which the gases pass must be capable of being kept partly and equally distended during the administration :

(3) The bags must be as close as possible to the face-piece :

(4) The channels throughout the apparatus must be sufficiently large to avoid any stress whatever being thrown upon respiration :

(5) The regulating portion of the apparatus must allow of very small increments and decrements in the proportion of oxygen breathed with the nitrous oxide :

(6) There must be accurately working valves: (*a*) for preventing all re-breathing,

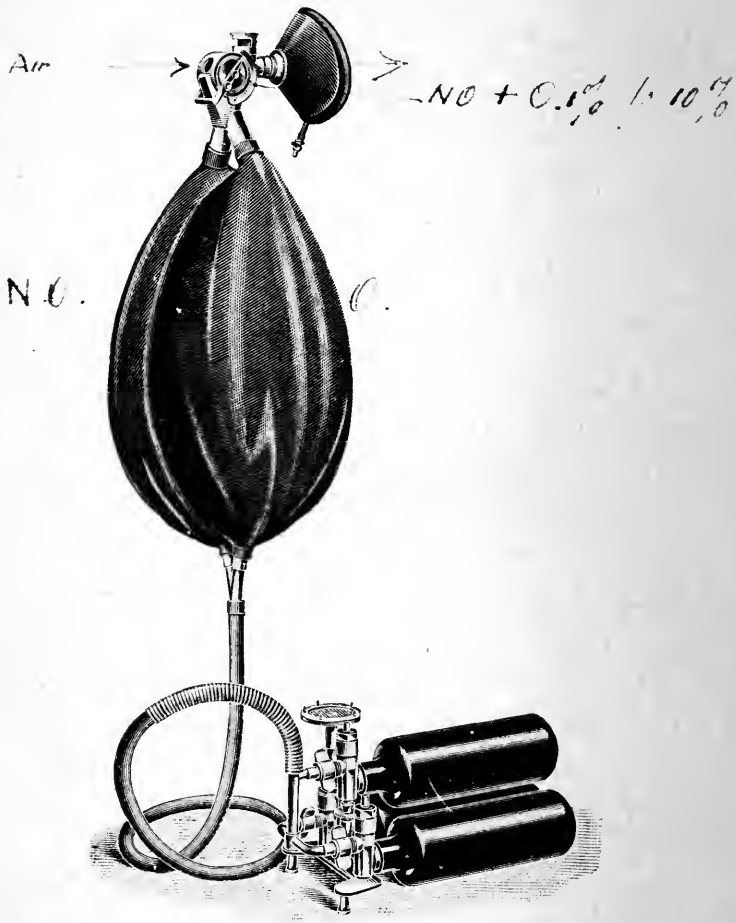

FIG. 1.—The Author's apparatus.

and (*b*) for preventing diffusion between the contents of one bag and the contents of the other:

(7) The expiratory valve must not allow of any air being sucked back during its closure in the inspiratory phase :

(8) The apparatus must be so constructed that, when first applied to the face, air will be breathed freely through it, and through the same valves that will be subsequently used when the mixture is turned on :

(9) The apparatus must admit of being readily taken to pieces without the use of tools, so that its various parts may be inspected from time to time :

(10) The inhaling portion of the apparatus must admit of being thoroughly cleansed, and of being treated with antiseptic solutions should occasion require.

(11) The whole apparatus must be sufficiently portable to be carried in a hand bag. (See Fig. 5.)

Fig. 1 represents the **complete apparatus.** It consists of **two nitrous oxide cylinders, one oxygen cylinder, a combined stand and union, double india-rubber tubes** (one running inside the other) for conducting the two gases from the cylinders to the bags, **two india-rubber bags** joined together by a septum common to both, a **combined regulating stopcock and mixing chamber,** and a **face-piece.**

The two **nitrous oxide cylinders,** the single

oxygen cylinder resting upon them, and the combined **stand** and **union,** are shown in diagrammatic section in Fig. 2.

Each nitrous oxide cylinder will furnish 50 gallons of nitrous oxide gas; and each oxygen cylinder about 15 gallons of oxygen.

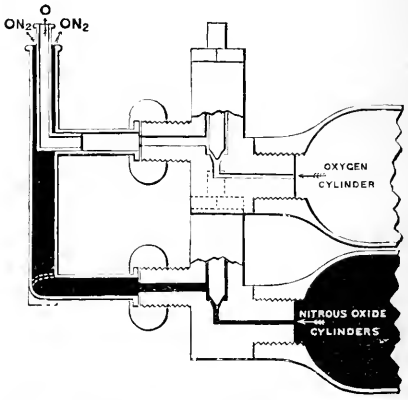

FIG. 2.—Diagrammatic section of cylinders, and of combined stand and union.

The combined stand and union is so made that the cylinders can be connected together or disconnected without the aid of spanners or other appliances. In order to prevent undue strain to the union when the foot-key is being used upon the oxygen cylinder, an adjustable screw pillar, fixed to the stand below, is made to engage that part of the under surface of the oxygen cylinder upon which foot-pressure directly tells. In this way all foot-pressure is transmitted to the stand.

When the foot-key is placed upon one of the nitrous oxide cylinders, and is turned, the liberated nitrous oxide passes to its bag through brass and india-rubber tubes of com-

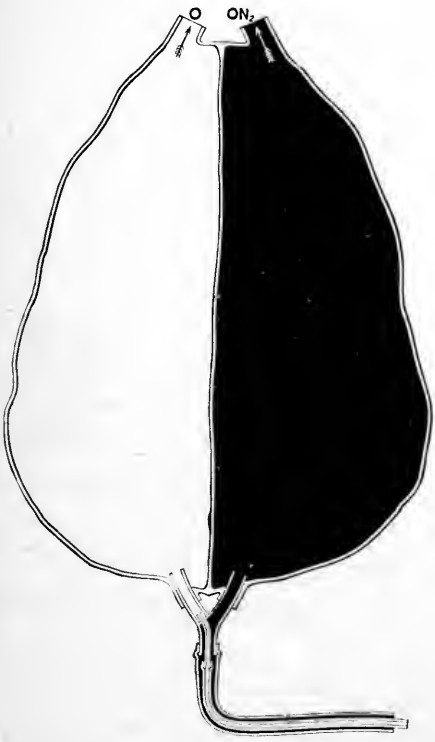

FIG. 3.—Diagrammatic section of the india-rubber transmitting tubes and bags through which the two gases pass on their way to the regulating stopcock and mixing chamber.

paratively large calibre. When oxygen is similarly released from its cylinder it passes to its bag through brass and india-rubber

tubes which are so much smaller than the nitrous oxide tubes that they are made to travel inside the latter. Thus, in Fig. 2, it will be seen that, in the combined stand and union, the metal transmitting tube for the oxygen is inside that for the nitrous oxide.

Fig. 3 shows, in diagrammatic section, the two india-rubber **transmitting tubes**, one inside the other, conveying their respective gases to the two india-rubber **bags.** These bags are of about equal capacity, and are so made that a rather thick india-rubber septum is common to both. When full they have the outward appearance of a single bag. Care is needed to prevent the india-rubber from becoming punctured or otherwise injured. Even if only one or two minute punctures exist, they may be quite sufficient to allow of an admixture of atmospheric air. The bags, moreover, must not be too small; otherwise it may be difficult or impossible, during the administration, to keep the nitrous oxide bag equal in size to the oxygen, especially if the patient should breathe very deeply.

The **regulating stopcock and mixing chamber** is shown in detail in Fig. 4. The nitrous oxide bag (see Fig. 3) is attached to the tube NOT, the orifice of which, NOO, is shown. The oxygen bag is attached to OT, which communicates above with a little oxygen cham-

ber OC. There are ten minute holes between the oxygen chamber OC and the mixing chamber. Only three of these ten holes, OO,

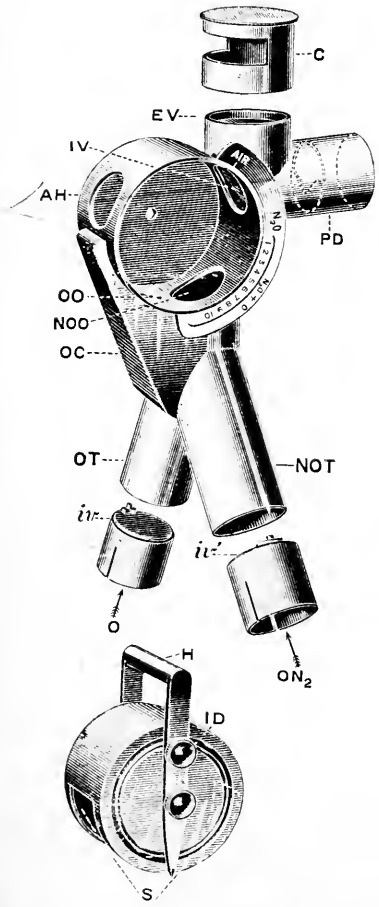

FIG. 4.—Regulating stopcock and mixing chamber.

appear in the figure. The tubes, OT and NOT are furnished with removable valves, *iv*,

and *iv'*, which act during inspiration, and which prevent diffusion between the gases of the two bags. AH is the air-hole. IV is the main inspiratory valve. EV is the expiratory valve, with its chimney C.

PD, shown in dotted outline, is a partial diaphragm, mounted upon a removable inner tube, which serves to direct the expirations towards the expiratory valve EV. In the absence of this partial diaphragm there is a tendency for the expirations to pass back again beneath IV, and so to throw the valve-action completely out of gear.

The chimney C is essential in preventing air being drawn back through EV during its closure at each inspiration.

The inner drum, ID, which is made to revolve by means of the handle H, has a large portion of its circumference cut away to form a long slot S. The handle H is prolonged into an indicating point or indicator.

To the circumference of the stopcock and mixing chamber is fixed a flange with "AIR," "N_2O," and "$N_2O + O$," engraved upon it. There are also figures, from "1" to "10" inclusive, belonging to the "$N_2O + O$" part of the flange. When the indicator of the handle H points to "AIR," as in Fig. 1, the slot S of the drum ID allows air to pass through AH and IV during the act of inspiration: but by

reason of the other part of the drum covering the orifices NOO and OO, nothing but air is breathed. When the indicator is moved to "N_2O," the drum closes AH, and opens NOO, the oxygen orifices still remaining covered. Pure nitrous oxide is therefore inhaled. When the indicator reaches "1" on the "$N_2O + O$" part of the flange, the nitrous oxide orifice NOO still remains open, but, in addition, one of the oxygen orifices OO, becomes uncovered by the revolution of the inner drum. When "2" is reached, two oxygen holes are open, and so on up to "10," the nitrous oxide orifice remaining patent throughout.

It may thus be said that directly the indicator is made to point to "N_2O," there passes through the stopcock a continuous and large stream of nitrous oxide, and that any number of small streams of oxygen, from one to ten inclusive may, at will, be added to this continuous stream of nitrous oxide. As the indicator reaches the various points on the flange an audible click is produced by means of a spring attached to the handle.

All the **valves** are made of thin sheet india-rubber, and it is important that they should be in good order. Should they become inelastic from age, or should they in any way fail to act, as they are intended to act, with perfect accuracy, the apparatus will not pro-

duce good results. For example, an apparatus may let through much larger proportions of oxygen than usual if the nitrous oxide valve *iv'* should happen to adhere, along a part of its circumference, to the rim upon which it rests ; the explanation being that the suction exerted by the inspirations of the patient would have a greater influence than usual in drawing oxygen from the oxygen bag owing to the abnormal resistance at the nitrous oxide valve. The valves of the apparatus are so arranged as to act most efficiently when the main expiratory valve is kept as horizontal as possible. If the whole apparatus be much tilted during use, as would be the case if the patient's head should be thrown very far back, the valves may not act efficiently.

The apparatus may be taken to pieces with the utmost readiness by simply removing, with the finger, the screws which connect the handle H to the inner drum ID. In this way the drum may be removed and the valves and oxygen orifices inspected. The latter may occasionally require to be freed from dust.

Three or four **face-pieces** of different sizes should be at hand. The air cushion of the face-piece employed should be only moderately inflated, otherwise it may not fit as well as is desirable.

In order that good and reliable results may

be obtained, it is important that the whole apparatus should be carefully handled. The process of anæsthetising with nitrous oxide and oxygen is a more delicate process than that involved in the ordinary administration of nitrous oxide alone; and trifling defects in the apparatus are liable to interfere with results. The connections must be tested; the bags inspected frequently; the stopcock taken to pieces occasionally—in fact, the anæsthetist must take a personal interest in his apparatus if he wishes to succeed with it.

A word may here be said as to the **relative proportions of nitrous oxide and oxygen** which the apparatus is capable of furnishing. As will be pointed out in the following chapter, much will depend upon the state of the bags during the inhalation, and especially upon whether they are kept of equal size throughout. But it is necessary to mention, in the present connection, that each apparatus possesses slight peculiarities of its own. It is a difficult matter to produce two models which will act in precisely the same way. The result is that the anæsthetist must observe what his particular apparatus is capable of doing. With one model it may not be possible to reach "8" upon the flange without excitement arising; whilst with another model "9" or "10" may be reached in

nearly every case without any such symptoms occurring.

But when once the anæsthetist has found out how far he can go with his particular apparatus he will always be able to depend upon it working in the same way, provided, of course, that he keeps its valves, oxygen holes, bags, and other parts in good order.

The apparatus is manufactured by Messrs. Barth & Co., of Poland Street, Oxford Street, to whom I am much indebted for the patience and skill they have shown in carrying out my designs. It may either he obtained from them or from Messrs. Ash & Sons, Broad Street, Golden Square.

CHAPTER III.

PREPARATIONS.

The old adage "Everything that is worth doing is worth doing well" forcibly applies to the use of anæsthetics in dental practice. It is only by attention to detail that success can be achieved in every case. The dentist who regards preparations and precautions as unnecessary, and who expects his colleague to entertain similar views, has only himself to thank when difficulties arise. There is no known method of anæsthetising which will succeed when the corsets are tightly laced, the stomach full, or the posture faulty. It is, I think, a mistake to suppose that patients are made nervous by the few preparations which are essential to success. I would rather say that most patients gain assurance when they see that pains are being taken to obtain the best results.

When practicable, **an interval of about four hours** should have elapsed between the

last meal and the administration. The middle of the day (from 12 to 2 o'clock) is a very convenient time for the extraction of teeth under anæsthetics. Precautions as to diet are especially important in the case of children, and when a long anæsthesia is needed (see p. 86).

Stimulants should, as a rule, be avoided. In very feeble subjects, however, and in those inclined to faint, an exception may be made if desired. I have notes of a child who was given by his parents some brandy and water before starting for the dentist's. A very unsatisfactory anæsthesia followed, and the little patient retched violently.

In the case of children, and even in that of adults, when circumstances permit, it is well that the **bladder should be empty.** Micturition during the administration is, however, exceedingly rare.

Whenever circumstances are favourable, it is a good plan to have **everything in readiness** before the patient enters the room. The anæsthetist should see that his apparatus is in working order; he should fill the bags with their respective gases to the extent of about two-thirds, so that they are equally and moderately distended; and he should leave the foot-key on one of the nitrous oxide cylinders ready for use.

The following appliances should always be in readiness:—**Mouth props** of various sizes, a **Mason's gag,** a pair of **tongue forceps,** some **nitrite of amyl** capsules, and **instruments for performing tracheotomy.** Although I have never had occasion to use tongue forceps, nitrite of amyl, or tracheotomy instruments in connection with this form of anæsthesia, it is nevertheless important to be fully prepared for all contingencies.

A **third person** should always be present in the room from the time the inhalation is begun till the patient's consciousness is fully restored.

The administration should not be undertaken by the same person who performs the operation.

The importance of **loose clothing** cannot be too strongly insisted upon. In order that the induction of anæsthesia may be successfully accomplished, it is necessary that the air in the lungs should be exchanged as quickly as possible for the anæsthetic gas. In order that this may be effected, the *bases of the lungs must expand by diaphragmatic action.* If there be tightly-fitting corsets or waist bands, the diaphragm cannot descend fully; the breathing will be restricted and to a great extent, or entirely, thoracic; interchange between the air in the lungs and the anæsthetic will only

take place freely in the upper parts of the lungs; and the onset of anæsthesia will therefore be delayed. Patients who are tightly laced may do their best to quickly fill their lungs with the anæsthetic gas, but they will fail. All constricting clothing about the upper part of the chest and neck should also be loosened with the object of allowing respiration to proceed perfectly freely. It is not a bad plan for ladies to come to the dentist's loosely attired, so that no further preparation in this direction need be made.

The **posture** of the patient has a very decided influence in modifying the phenomena of anæsthesia. I have so recently entered at length into this subject that I must refer the reader to my paper[25] specially dealing with it. I may, however, say on the present occasion, that whenever circumstances permit, the patient should be allowed to assume a comfortable and unrestrained posture, and that his head should be permitted to retain its natural position in regard to the body, being neither flexed upon the chest nor extended toward the spine (see fig. 5, p. 44). Good results cannot be expected if the administration be begun when the patient's head is thrown back upon the spine. Should the operator wish to have the head thrown more backwards than is represented in the figure, the best plan is to anæsthetise the

patient in the posture depicted, and to tilt the whole chair backwards just before the face-piece is removed for the commencement of the operation. In this way the proper angle for the operation will be obtained without disturbing the normal relations of the head to the trunk. Should the chair not admit of this movement, an inflated air pillow should be placed under the head before commencing the administration, and, just before the face-piece is removed, the air may be allowed to escape. In this way the head will fall into the extended position ready for the operation, and the comfort of the patient, as well as the convenience of the operator and of the anæsthetist will have been provided for.

If any **relatives** or **friends** of the patient be present they should be requested to remain in an adjacent room during the administration and operation. Should they express a desire, however, to be present, they should not be permitted to stand near the chair, or to hold the patient's hand, as such attentions will almost certainly have an opposite effect to that which is intended, and will introduce a disturbing element into the anæsthesia. In many cases friends wish only to be present during the induction of anæsthesia, and there is little to be said against this: directly consciousness has been lost, a signal should be given them in order that they may retire during the actual

operation. Owing to the fact that by the use of oxygen with nitrous oxide, a far more tranquil and sleep-like anæsthesia is produced than with nitrous oxide alone, there is less objection to friends being present than under other circumstances.

A suitable mouth-prop should be inserted immediately before the administration is begun. The prop which I employ is fully described elsewhere.[12] It is made of aluminium, and is so shaped that it rarely if ever slips when once put into position. It is important in fixing the prop that the mouth should be opened as widely as possible, except when stretching the lips would inconvenience the operator, or when widely opening the mouth would give the patient great discomfort, or excite retching movements. In the extraction of wisdom teeth it is usually a good plan not to open the mouth to its fullest extent. Should the insertion of the prop excite retching movements, the remedy which usually answers is an exceedingly simple and efficient one. The patient should first be requested to breathe deeply through the open mouth, to count his respirations to himself, and to concentrate his whole attention on these points. The prop is then put in whilst he is thus breathing and counting; the face-piece is quickly applied; the gases are admitted; and if the patient

continue to fix his attention on the points suggested, he will pass into anæsthesia without the recurrence of any retching movements.

CHAPTER IV.

THE ADMINISTRATION.

With the object of making this part of the subject as clear as possible, it will be well to confine our attention in the present chapter to the details of **an ordinary or average administration,** and to the effects which such an administration produces in **an ordinary or average patient.** As the majority of those who require anæsthetics in dental practice are women, it will be advisable to take as our normal type a young woman, of medium height and build, of medium complexion, and not markedly nervous. When we have fully considered the method which should be adopted in anæsthetising such a patient we shall be in a position to discuss, in a subsequent chapter, the slight modifications in procedure which are essential in dealing with other types of patients.

An endeavour should be made to **avoid all disturbing influences** during the administration. The room should be kept quiet. Friends should

not be permitted to hold the patient's hand. There is no objection to the operator holding the hand of a nervous patient if confidence is likely to be gained in this way. The anæsthetist should say a few words to the patient during the first moments of the inhalation, but not a word should be uttered after this, until the operation has been completed. With nervous subjects it is often a good plan for the anæsthetist to count aloud, as the patient breathes. Under any circumstances the anæsthetist should instruct the patient how to breathe. The anæsthesia is likely to be disturbed by any conversation, loud noises, the comments or questions of anxious friends, &c. Even feeling the pulse at the wrist is likely to induce nervousness, and should be avoided. In a word, the patient should be left as much as possible to herself.

When considering, in Chapter III., the preparations which are necessary before an administration is commenced, it was stated that the bags containing the nitrous oxide and oxygen should, if possible, be charged with their respective gases, and that the foot-key should be placed upon one of the nitrous oxide cylinders, before the patient enters the room.

The patient having assumed a perfectly comfortable posture, and a mouth-prop having been adjusted, the face-piece should be applied.

Air will now be breathed through the apparatus, each expiration escaping at the expiratory valve.

FIG. 5.—The administration.

The anæsthetist should request his patient to take long deep breaths, backwards and forwards, through the mouth. Nasal breathing

should be avoided. If there is any "holding the breath" or hesitation in breathing, this must be corrected before proceeding further. The most absolute co-aptation of the face-piece is essential. The sound made by the flapping of the valves is the best proof that the face-piece is fitting well; and this sound should always be heard before the mixture is turned on.

When it is clear that the face-piece fits accurately, **the indicator,** which has hitherto been pointing to "AIR," **should be turned to "2."** At the same moment the foot should slightly turn the foot-key in order to quickly replace the nitrous oxide which the patient is breathing.

It is impossible to state, with precision, what percentage of oxygen will come through when the indicator is thus turned to "2," for one apparatus will be found to differ slightly from another, and much will depend upon the relative sizes of the bags at the moment. It is sufficient for our purpose that quite a small percentage—roughly about 2, 3, or 4 per cent. —will be first breathed. The percentage is so small, indeed, that the oxygen bag hardly appears to alter in size throughout, and no further addition to it from the oxygen cylinder is necessary in dental administrations, even in the case of long inhalations.

The **initial sensations** of the patient are very similar to those experienced under nitrous oxide itself, and are by no means unpleasant. I am still unable to decide whether the almost invariable absence of suffocative sensations is referable to the presence of the small proportion of oxygen, or whether it is due to the very free channels of the apparatus. It is, however, certain that patients hardly ever experience the slightest discomfort in breathing the mixed gases, provided, of course, that the clothing is perfectly loose. Consciousness is not lost quite so quickly as with nitrous oxide alone; but in other respects the early sensations are identical, and need not therefore be described.

The anæsthetist has now to pay attention to **three points** at the same time. He has (1) to keep the face-piece very accurately applied; (2) to keep the two bags equally and only partly distended; and (3) to increase or diminish the proportion of oxygen according to the symptoms of the patient. It will therefore be advisable to consider the remaining part of the administration under these three heads.

(1) **The fitting of the face-piece.** Whilst there is much to be said in favour of the face-piece, as opposed to the mouth-tube, for nitrous oxide inhalation, there can be no doubt that it is more difficult, when employing the former, to

completely exclude atmospheric air than when using the latter. There are, however, several objections to mouth-tubes. The idea of holding between one's lips a tube that has just been used by another patient is not a pleasant one, even though the most scrupulous cleanliness may have been enforced. Moreover, it is essential, in using a mouth-tube, that the nose should be clipped or held, in order to prevent any air entering the nasal passages. And, lastly, breathing is liable to be impeded by the tube necessarily being of small calibre. Taking everything into consideration, therefore, the face-piece has distinct advantages. But considerable practice is required before perfect coaptation can be secured in all cases. Unfortunately, when employing the mixed gases, any want of coaptation cannot be met by increasing the pressure at which the gases enter the face-piece, for distension of the bags would at once throw the regulating mechanism out of gear.

(2) **The fulness and relative sizes of the bags.** In order that the regulating mechanism may work properly it is necessary that the two bags should be kept as nearly as possible of equal size throughout, and only partly distended. The anæsthetist has, in fact, to use his foot as much as his hand, and to let in nitrous oxide to its bag in such quantities that

the bag remains the same size as the oxygen bag. The latter necessarily grows gradually smaller, and the anæsthetist, therefore, has to keep the nitrous oxide bag less and less full.

(3) **The Admission of Oxygen.** Given that the apparatus works satisfactorily and in the usual manner, the anæsthetist must regulate the admission of oxygen in accordance with the type of his patient, and with the symptoms that the patient displays. There is, unfortunately, no rule which will apply to every case. After some experience the administrator will recognise that he has at his disposal an apparatus by which he can, if he wishes, obtain two totally different groups of symptoms.

If very little or no oxygen be given, the ordinary phenomena of nitrous oxide narcosis will present themselves, viz., blueness, lividity, or duskiness of the features, epileptiform muscular twitchings of the trunk, extremities and face, and obstructive stertor.

If too much oxygen be admitted, there will be no alteration in colour, no epileptiform convulsive movements, and no stertor, but violent mental and muscular excitement (laughter, shouting, kicking, stamping and struggling) will attend the administration, and will be almost as objectionable as the asphyxial phenomena produced by pure nitrous oxide.

There are thus two extremes—two ends of

the scale—and each extreme must be avoided. The anæsthetist has, in fact, to steer a middle course, and to keep a sharp look-out. A little practice will enable him to avoid the Scylla of asphyxia on the one hand, and the Charybdis of excitement on the other. He will find, after a time, that he is able to detect even slight deviations from the proper course, almost before such deviations have taken place.

Generally speaking, a gradual and progressive increase in the percentage of oxygen is advisable. In such a case, for example, as that which we have pictured to ourselves, the best results will be obtained by starting the inhalation, as already mentioned, with from 2 to 4 per cent. of oxygen, and then progressively increasing this proportion to 8 or 9 per cent. It seems to me that it is a mistake to adopt the plan which is customary in Germany, and to begin with as much as 10 per cent. of oxygen. It is surely more rational to make an allowance for the oxygen present in the lungs when the administration begins, and we should therefore commence with a very small percentage of this gas. As the lungs lose the air they contained, so the percentage of oxygen in the mixture may be increased, provided that no symptoms of excitement arise. If a 10 per cent. mixture be used from the commencement, excitement is liable to ensue from the undue

proportion of oxygen. Witzel,[19] for example, who follows this course in his administrations, finds it necessary to employ arm-rings, foot-straps, and other appliances to restrain the patient's movements, and to have at hand, on all occasions, strong and trained assistants. Such precautions are unnecessary when the method here advocated is followed.

I find it best, as a general rule, to allow two or three inspirations of the mixture to take place with the indicator at "2"; two or three more with it at "3"; two or three more with it at "4"; and so on till "6" or "7" is reached. Usually, by the time the indicator has reached this point the anæsthetist will be able to recognise the existence of one of three conditions. There will either be evidence to show

(α) that the proportions of the two gases are **properly adjusted;**

(β) that the proportion of oxygen is rather **in excess** of that which is needed, and should therefore be diminished;

or (γ) that this proportion is rather **less** than that required, and should therefore be increased.

(α) The absence of any indications of excitement on the one hand, or of asphyxia on the other, will prove that the proportions of the two gases are properly adjusted. Under such circumstances the indicator may either

be kept at "6" or "7" for several breaths, and then gradually turned to "8," "9," or "10," or it may be allowed to remain at "6" or "7" till anæsthesia is fully and satisfactorily established.

(β) Should there be an unaltered colour, associated either with slight phonation, hardly perceptible breathing, a tendency to laughter, or slight restless movements of the head, trunk, or extremities, the oxygen indicator should be turned back slightly; for these symptoms indicate that too much oxygen is being inhaled.

(γ) Should the breathing be loudly snoring in character, or the colour rather dusky, or should slight general clonic movement of the body, head, or extremities be evident, the oxygen indicator must be moved on; for such symptoms indicate a deficiency of oxygen.

In one or other of these three ways the patient will pass into **deep and satisfactory anæsthesia characterised by certain definite phenomena.** The experience of recent years has convinced me that in administering nitrous oxide and oxygen we should endeavour to obtain an anæsthesia similar in most of its features to the best types of ether or chloroform anæsthesia. If we aim at inducing a perfectly sleep-like state in which the colour of the features is absolutely unaltered or is even heightened, and the breathing is so tranquil

that it is inaudible, we shall not only be liable to meet with excitement, but the anæsthesia will, at all events in many cases, be less profound than is desirable. Moreover, it is not an easy matter, when the breathing is inaudible, to estimate the depth of anæsthesia. We should therefore, I think, endeavour to bring about an anæsthesia characterised by **softly snoring breathing, a good pulse, a colour as near the normal as possible, an insensitive ocular conjunctiva, relaxed eyelids, a fixed condition of the globes, and the absence of muscular rigidity in the extremities.**

Sometimes, and especially after a phase of rapid breathing, or when a good deal of oxygen has been given, the **respiration may come almost or completely to a standstill** without there being the slightest need for alarm. The apnœic state is associated with a good pulse and colour, and will quickly pass off when the proportion of oxygen is reduced.

The **pulse** is always as quick as, or quicker than it was immediately before the administration. In most cases the initial acceleration from nervousness gradually increases to a maximum, and then declines somewhat, though it never falls below its initial acceleration rate. I am unable to agree with Hillischer's observation that the pulse-rate sinks to normal during anæsthesia. Dr. Oliver[1] observed, in using

his arteriometer, that the pulse calibre was not reduced as in the case of pure nitrous oxide. The small, feeble, and exceedingly rapid pulse which not unfrequently may be felt at the acme of an ordinary nitrous oxide inhalation, is not met with when oxygen is present with the nitrous oxide in sufficient quantities. I have never, in fact, come across any indications of circulatory failure during the administration of the mixed gases. The tongue and adjacent structures are less engorged than when nitrous oxide is administered free from oxygen.

The **eyes** are generally closed throughout. Some patients, however, prefer to keep them open when the inhalation begins, but as it proceeds the globes gradually cease to fix themselves on surrounding objects, and the lids become approximated. During the first minute or so of the inhalation any attempt on the part of the administrator to raise the upper lid will be resisted by the patient. But after the first minute the lid will gradually relax ; and when it can be raised without any resistance, and the conjunctiva can be touched without reflex response, it may generally be assumed that sufficient anæsthesia is present. Sometimes fine oscillatory movements of the globes may be seen on raising the upper lids. The pupils are generally of medium size or moderately dilated. There is a striking contrast between the closed lids of this form of anæsthesia and

the open and turned-up eyes so often seen in ordinary nitrous oxide narcosis.

Amongst the numerous points to which attention must be paid in conducting the administration, there is one which is of considerable importance. It is that the anæsthetist must allow for what may be termed the **delayed effects** of admitting more or less oxygen. For example, let us suppose that slight phonation occurs when the indicator points to "7." By turning it to "3" or "4" the phonation will in the course of a few moments subside. But if the indicator be kept at "3" or "4" till the patient is perfectly quiet, the anæsthetist will probably have gone too far in the asphyxial direction. He should turn to "3" or "4" for a few breaths only and return to "5," "6" or "7" before the phonation has ceased. In other words, he must bear in mind that a little interval must necessarily elapse before the effects of an increase or decrease in oxygen admission will become manifest.

As regards the **length of inhalation** which is necessary to produce the typical phenomena of the anæsthesia, I have found that it is, on the average, 110 seconds, *i.e.*, nearly twice the length of the average nitrous oxide inhalation. The juncture at which the administration should be terminated must, however, depend

upon the circumstances of each case, such, for example, as the susceptibility or insusceptibility which the patient has displayed, the nature of the proposed operation, and the length of time that has elapsed since food was taken.

The **quantity of the mixture required** to produce anæsthesia will likewise vary considerably, being dependent upon the proportion of oxygen employed, the depth and rate of respiration, the length of inhalation, the type of patient, and other factors.

CHAPTER V.

THE PATIENT.

In studying the effects produced in the human subject by nitrous oxide and oxygen, one of the first facts which becomes apparent is that, although the constitution of the mixture, the method of administration, and other surrounding circumstances may remain the same, different individuals display very different phenomena. To say, however, that every case has its own special peculiarities is hardly correct. By careful observation it becomes possible to group cases together into classes, and to say that patients of this or that class will display this or that set of symptoms. We are in this way led to speak of **different types of patients.** It is true that our knowledge of this interesting aspect of the subject is still very meagre; but it is rapidly increasing. Success in administering anæsthetics is largely dependent upon the power the administrator possesses of correctly foretelling what effects this or that method will produce in the patient before him;

and it is this kind of knowledge which is essential in deciding upon the particular lines of treatment which should be adopted in anæsthetising patients by the method now under consideration.

In the preceding Chapter we discussed the plan which should be followed in dealing with those types of subjects most commonly met with. We have now to consider what modifications in that plan are advisable when anæsthetising patients of other types.

Sex and age.—In anæsthetising small children, more oxygen than usual must be admitted. Should crying take place, the administration should be commenced with the indicator at "8" "9" or "10"; for the crying tends to introduce an asphyxial element. I have anæsthetised two or three children of three years of age, by means of the mixture, but with moderate success only, the anæsthesia being very transient in such small subjects. In older children the indicator may usually be placed at "3" or "4" to commence with, and moved on rather more quickly than usual to "5," "6," etc. By the time "10" is reached, the breathing will probably have become so tranquil that some doubt as to the presence of anæsthesia may be felt; the indicator should therefore now be turned back to "5," "4" or even "3," when snoring will be certain to com-

mence. In this way a more satisfactory anæsthesia may be induced than if the face-piece be removed during the inaudible breathing.

Taken as a class, women are better subjects than men. They are more tolerant of considerable proportions of oxygen, they are more susceptible to the mixture, and, by reason of their being less muscular, they are less prone to inconvenient rigidity and movement. Middle-aged women, with the rarest exceptions, are always good subjects. I have, for example, notes of several cases in which 60-90 seconds' anæsthesia resulted after an ordinary inhalation of the mixed gases.

Old persons of both sexes are always very favourably affected by the mixture. I have anæsthetised, by its means, several patients over 80 years of age. The absence of that temporary respiratory embarrassment which is so often induced by nitrous oxide free from oxygen, and which, in the case of elderly persons with rigid chests, cannot be regarded as free from risk, is a very distinct gain.

General condition.—The better the patient's state of health the more anæsthetic will he require; and *vice versâ*. The proportions of oxygen in the mixture, moreover, should be rather smaller in the case of a perfectly healthy subject than in that of a debilitated individual. An exuberance of health and spirits is not

always conducive to the most tranquil form of anæsthesia. It may be said, in fact, that patients of a weakly constitution, and those who have recently been suffering from some depressing malady, more often approach our ideal standard of anæsthesia than patients of opposite types.

Physique.—Other things being equal, the more powerfully built the patient the greater will be the quantity of the mixture required. Men of an athletic physique, who have led out-door lives, and who are in a state of perfect health, often give slight trouble by becoming rigid during the administration and operation. Speaking in general terms, one may say that rather smaller proportions of oxygen should be used in the case of men than of women. Thus it is best, as a rule, to start the administration with the indicator at "1" and to very gradually move it onwards. If oxygen be admitted at the same rate as in anæsthetising women, a long inhalation will be necessary before good anæsthesia is established; and in attaining this anæsthesia excitement will be liable to arise. Men of slim build and rather weakly constitution may be treated in precisely the same way as women. Very stout subjects, and especially those with thick, short necks, or double chins, tend to become unusually stertorous. In such cases the respiratory functions are always

somewhat impaired, so that, even though the patient may be tall and powerfully built, it is best to proceed in the customary manner and not to diminish the usual proportions of oxygen. Very stout elderly women, with feeble heart action, and possibly bronchial symptoms, are remarkably good subjects for nitrous oxide and oxygen administered in this way.

The presence of a beard or moustache.—When the hair is so distributed about the lips and chin that even a small quantity necessarily intervenes between the cushion of the face-piece and the skin, allowance must be made for the unavoidable ingress of a small proportion of air with the mixture. All one can do is to obtain as accurate a coaptation as possible, by moistening the beard; to administer a few breaths of pure nitrous oxide at first; and then very gradually to turn to "1," "2," and so on. In this way I have been able to obtain very good results. In many cases the long inhalation which has resulted from the unavoidable admission of small proportions of air, has led to remarkably long anæsthesia. It is impossible, however, in these cases, to be as sure of one's results as in others.

Temperament.—Other factors remaining the same, the best subjects for this as for other anæsthetics are patients with placid, equable

temperaments. Highly excitable and emotional persons are liable to give slight trouble. They sometimes voluntarily hold the breath, or scream, before the anæsthetic is actually breathed. They often, moreover, require considerable quantities of the mixed gases before the conjunctival reflex vanishes. In many cases, indeed, this reflex will not disappear, and the anæsthetist has to judge by other signs that his patient is ready for the operation.

Highly neurotic persons usually display a shorter available anæsthesia than others. Thin, pale, dark-complexioned young women, of nervous temperament are particularly liable to prove difficult of management. With nitrous oxide alone the full effects of the gas are produced in a few respirations; the asphyxial element is conspicuously present; and the resulting anæsthesia is disturbed and brief. Much better results may be obtained, however, with the mixture if the administration be conducted properly. Oxygen should be rather sparingly admitted at first; it should then be somewhat more freely given; and a long inhalation secured. With regard to hysterical women, we may say that, although one cannot always depend upon obtaining perfect results, such patients are, as a rule, remarkably good subjects for the mixture.

provided that oxygen be not too freely admitted. When such subjects are anæsthetised by nitrous oxide alone, the anæsthesia is so short that during recovery nightmare-dreams and other distressing sensations are likely to arise, and to induce screaming and emotional attacks. The anæsthesia being deeper, when the mixture is used, the resulting unconsciousness is quieter and longer, and the recovery is usually unattended by any emotional disturbances. The difference between the two methods of anæsthetising dental patients has been very marked during the course of the work I have done at the Dental Hospital. I find that with nitrous oxide and oxygen, patients rarely make any sound at all, either during or after the administration; whereas with nitrous oxide alone, phonation is exceedingly common.

Complexion - Colour. — Plethoric, florid patients are more liable than anæmic looking persons to evince some duskiness during the inhalation. Of all subjects, however, those of a congested, bloated aspect are the most prone to become dusky in appearance. It is not advisable to be guided entirely by the patient's colour in deciding whether more or less oxygen should be given; for if this course be adopted in the case of patients who quickly and readily show slight duskiness, but who are naturally

excitable, imperfect anæsthesia from too much oxygen may arise. In most cases it is possible to retain the patient's normal colour throughout the administration. Curiously enough, I have notes of one or two cases, in which no obvious alteration in colour occurred even though, as was obvious from the presence of "mild oscillation," the oxygen of the mixture was considerably reduced. These cases are very exceptional. Should the patient be pale from nervous apprehension, the pallor will become replaced by the natural colour as the inhalation proceeds. Generally speaking, anæmic subjects are very tolerant of oxygen, and in their case this gas should be admitted more freely than usual, the indicator being placed at "3" or "4" at the beginning of the administration.

Alcoholic indulgence. — Alcoholic subjects generally do well with rather less oxygen than usual, and the administration should be as prolonged as is considered advisable, in order to produce as deep an anæsthesia as possible. As with other anæsthetics, delay in producing anæsthesia is liable to arise, and the anæsthetic state is often short and imperfect in character. Movements of the head, arms, or legs are not uncommon during the inhalation, so that care should be taken not to give more oxygen than is needed to avoid asphyxial phenomena. In

some cases the hands of the patients will clutch the operator's arm during the operation, even in the complete absence of consciousness. Reflex phonation during the operation is also not uncommon.

The excessive use of tobacco and other narcotics.—I have found that patients who smoke inordinately are not the best subjects for nitrous oxide, even when given with oxygen. They are inclined to movement, hesitating or suspended breathing, and rigidity, during the inhalation, and to a short anæsthesia afterwards. All one can say is that one can obtain, by means of the mixture, a better result than with nitrous oxide alone; but this is all. Patients who habitually take chloral or morphine also become comparatively insusceptible to this as to other anæsthetics. I have only once met with a temporary maniacal seizure after nitrous oxide and oxygen, and this was in the case of a young man who, for six consecutive nights, had taken sleeping draughts of chloral and of opium.

Affections of the respiratory system.—Should any affection of the respiratory system exist, care must be taken to allow for this, so to speak, in conducting the administration, otherwise asphyxial phenomena similar to those met with when nitrous oxide is administered in the customary manner, will be liable to arise.

If the air-way be partly obstructed by large tonsils, adenoid growths, or other conditions; if the patient be the subject of chronic bronchitis, emphysema, phthisis, or other allied diseases; or if breathlessness from some cardiac affection be present; more oxygen than usual must be given in order to neutralise, as it were, the unusual asphyxial element in the case. If this be done, nitrous oxide anæsthesia may be safely induced in nearly every case.

There are, however, a few highly exceptional conditions in which some other form of anæsthesia is perhaps preferable. I refer particularly to patients suffering from such dyspnœa that no tightly-fitting mask can be applied—patients, for example, who are the subjects of aneurysmal or other pressure upon the trachea, very advanced phthisis, hydrothorax, and other grave respiratory conditions. Putting such exceptional cases on one side, we may safely administer nitrous oxide and oxygen to all other patients.

Affections of the circulatory system.—It is well known that patients with diseases of the heart are good subjects for anæsthetics, provided that care be taken in selecting appropriate methods.

I have administered nitrous oxide and oxygen to patients with all the commoner

forms of morbus cordis. Amongst these have been three cases of aortic regurgitation, one of advanced mitral and aortic disease, and one of congenital valvular disease (? pulmonary). In all of these cases excellent results were obtained, and no anxiety was experienced. Although nitrous oxide, as ordinarily administered, is generally regarded as safe even in advanced heart disease, I must confess that I prefer not to adopt the customary plan of administration in such subjects. The case is quite different when nitrous oxide is given with oxygen, for the temporary impairment of respiration, with its consequent temporary general venous engorgement, is prevented, so that no undue strain is thrown upon the right side of the heart. I have notes of an interesting case which occurred at the Dental Hospital, which is perhaps worth quoting. The patient was a pale, thin, breathless man, who had been an in-patient at Charing Cross Hospital with œdema of the legs and cardiac symptoms following rheumatic fever. He was stated to have double aortic and mitral disease. The heart's action was very tumultuous and irregular. Nitrous oxide, free from oxygen, was administered to him by a skilled anæsthetist on two occasions. On one of these his pupils became enormously dilated, his breathing very difficult, and his conjunctiva

insensitive. His appearance was so alarming that no operation was performed. The tongue was drawn forwards, and gradually the threatening symptoms vanished. I subsequently administered nitrous oxide and oxygen to this patient. The pupils never became widely dilated, and no trouble whatever occurred. In the case of a lad with aortic regurgitation, who was pale, probably from fright, before the administration, the pulse markedly improved as the inhalation proceeded, and the pallor lessened; during the operation the normal florid colour was completely restored. I have observed exactly the same train of symptoms in a patient who, at the time of the administration, had an exceedingly feeble pulse, and was pale from shock produced by fruitless attempts to extract a tooth without an anæsthetic. One patient to whom I administered the mixture was the subject of a large intra-thoracic aneurysm; no bad effects followed. In elderly persons with atheromatous vessels, it is probably better to administer nitrous oxide and oxygen than nitrous oxide alone; but the present state of our knowledge concerning the differences in arterial tension in the two cases prevents any positive statement being made.

Affections of the nervous system.—I have

anæsthetised numerous epileptics, and have not yet met with a case in which an epileptic attack has arisen during or immediately after the inhalation. I have, however, had experience of one case in which a well-marked seizure took place during the administration of pure nitrous oxide; but as the attack came on very early in the administration it would be wrong, I think, to assume that the absence of oxygen had any influence in its causation.

Pregnancy. — Nitrous oxide and oxygen may be safely given to patients during the latter months of pregnancy. Although nitrous oxide, free from oxygen, is generally regarded as admissible, it certainly seems to me that it is wiser to adopt a non-asphyxiating method in these cases. I have administered nitrous oxide and oxygen, for a dental operation, within a week of the expected confinement, and without any difficulty or subsequent trouble arising. This plan of obtaining anæsthesia, indeed, is of great value in such cases, for on the one hand we are able to avoid the asphyxial accompaniments of an ordinary nitrous oxide inhalation, and, on the other, the possible after-vomiting of ether or chloroform narcosis.

CHAPTER VI.

THE ANÆSTHESIA.

The anæsthesia which is available for a dental operation commences at the moment the face-piece is removed, and should be regarded as terminating at the first indications of returning semi-consciousness. Nothing has contributed more to the unfavourable opinions held by the public concerning "laughing gas," than the practice of continuing the operation whilst the patient is emerging, or after he has emerged from deep anæsthesia. With pure nitrous oxide the available unconsciousness is comparatively short, and the transitional zones between deep anæsthesia, semi-anæsthesia, and normal consciousness are so narrow that errors of judgment as to whether or not the patient is capable of feeling pain at a given moment are to a certain extent excusable. But with nitrous oxide and oxygen the available anæsthesia is distinctly longer, and the transitional zones are distinctly broader, so that operations which do not admit of being per-

fectly painlessly performed under nitrous oxide as customarily administered, may be conducted with an absolute freedom from pain and discomfort under nitrous oxide and oxygen.

Immediately the anæsthetist has removed the face-piece he should direct his attention to **supporting the patient's lower jaw,** or **steadying the head,** according to the nature of the operation. He should at the same time keep a sharp look-out for teeth or fragments of teeth falling or shooting backwards towards the fauces.

It is generally customary for lower teeth to be removed before upper. If both sides of the mouth are to be operated upon, and if the order of events is a matter of indifference to the surgeon and to his patient, it is better for the left side to be first dealt with, for it is easier to introduce the Mason's gag, should one be required, from this, *i.e.*, the side upon which the anæsthetist stands, than from the other.

The **duration of the available anæsthesia** varies somewhat in different cases. The average duration is about 44 seconds. Other things being equal, the longer the inhalation, the longer will be the resulting anæsthesia. On many occasions, for example, I have continuously administered the mixed gases for three minutes, and have thus been able to

secure an available anæsthesia of 50, 60, or even 70 seconds. But although the duration of the inhalation has a very marked influence in determining the length of the subsequent unconsciousness, there are numerous other factors. The type of subject occupies a prominent position amongst these. Children, excitable, neurotic patients, alcoholics, and inveterate smokers, usually remain a shorter time than usual under the influence of the anæsthetic. On the other hand, anæmic, non-excitable young men and young women, middle-aged women of spare build, and persons of both sexes who are in indifferent health may remain tranquilly anæsthetised for a comparatively long time. The amplitude and rate of the breathing immediately after the face-piece is removed is another factor. Should the operation be such that the lower jaw becomes depressed towards the sternum, temporarily obstructed respiration may ensue, and this, by preventing the exit of the imprisoned anæsthetic, and the entrance of atmospheric air, may lead to a prolongation of the anæsthesia. The same result may be brought about by sudden alterations in the posture of the head, by which respiration becomes mechanically obstructed. A somewhat similar lengthening of the usual anæsthesia is occasionally observed in stout,

wheezy subjects, and in those with chronic bronchitis and emphysema; imperfect expansion of the bases of the lungs in these subjects being favourable to the retention of nitrous oxide and oxygen for a longer time than usual.

Generally speaking, the patient remains perfectly quiet and passive during the operation, provided that a proper limit be placed upon the latter. At the first application of the forceps or elevator, there is, however, in many cases, a very slight and not inconvenient **reflex movement** of the body. In exceptional cases the movement is greater.

Should the colour have been slightly dusky or paler than the normal when the face-piece was removed, it will quickly become natural when air is admitted. But if the operator should depress the lower jaw, or in any other way drive the tongue backwards, and thus temporarily arrest the breathing, some duskiness will necessarily be produced.

Phonation at the begining of the operation is hardly ever evoked. Should the patient have been making phonated sounds during the inhalation they may increase somewhat during the operation; but it is not uncommon for the exact reverse of this to take place, and for such sounds to be suddenly arrested when the tooth is grasped by the forceps. The available anæsthesia is far quieter and

of a better type than when nitrous oxide has been given free from oxygen. In exceptional cases, and more particularly in children and very nervous subjects, reflex phonation may occur, but as is well known, such phonation does not necessarily indicate the perception of pain or, indeed, any knowledge of the operation being performed. It is, moreover, usually not remembered.

There are unfortunately no systematic rules by which we can invariably tell when the available **anæsthesia has come to an end.** An endeavour should be made to so adjust the administration and the operation that after the latter has been completed there shall still remain a slight reserve of anæsthesia. In the event, however, of unexpected difficulties arising in the operation, the anæsthetist is rightly expected to give the signal for discontinuing the extraction. It is by no means always an easy matter to say whether, at a particular juncture, the operation should be terminated or continued. Nothing but practical experience is of any avail in deciding points of this kind. The general aspect of the patient, the state of the eyes and pupils, the character of any sounds that may be uttered, and the nature of any movements that may take place—these and other indications have to be taken into careful consideration.

The most successful cases are those in which the operation is performed at the acme of anæsthesia, so that not only is there an absence of all pain, but the patient experiences none of those unpleasant sensations which are likely to arise when an operation takes place during semi-consciousness.

A **re-application** of the face-piece before consciousness has been regained is not to be recommended, except under certain circumstances, for such a plan of procedure is almost certain to be followed by inconvenient if not by objectionable asphyxial effects. If, however, the patient's head be nearly vertical, if the attempt to remove a tooth or teeth should have led to no hæmorrhage, and if the face-piece be applied before inconvenient movement has taken place, there is but little objection to the re-application.

Generally speaking it is better, in the event of an extraction proving exceptionally difficult, to desist from the operation, to allow the patient to recover consciousness, to request him to thoroughly wash out his mouth with water, possibly containing a small quantity of sulphate of zinc or some other astringent, and to administer the mixture a second time. The circumstances will in this way be far more favourable than if a hurried attempt to extract a difficult tooth be made during imperfect

anæsthesia. Re-administrations of the mixture during partial or complete anæsthesia, as well as those conducted after an interval of several minutes' consciousness, are liable to induce nausea and vomiting, so that, whenever possible, they should be avoided.

In concluding this chapter it may be mentioned that there is no better anæsthetic than that under consideration for such operations as **drilling nto pulp cavities and opening up the antrum.** The absence of all jactitation and irregular breathing renders such operations far easier of performance than when nitrous oxide is used free from oxygen.

CHAPTER VII.

EXCEPTIONAL CASES.

Although the method of producing anæsthesia which has been described is the safest of all those at present known to us, it is undoubtedly the most complex. From this it follows that partial or complete failure to bring about typical nitrous oxide and oxygen anæsthesia will be liable to occur to everyone who has not had much experience of the method. As more and more experience is gained, it will be found that difficulties and exceptional cases are less and less frequently met with, and that eventually such a state of proficiency will be gained that cases displaying any unusual departure from the normal type will be exceedingly rare.

Laughter, Singing and Articulate Shouting. Inarticulate Phonation.—The occurrence of such symptoms during the administration indicates either that air is gaining admission with the mixture, or that the oxygen proportion is too high.

Muscular phenomena during inhalation.—These may comprise (1) Strictly voluntary movements at the outset of the administration, as, for example, putting up the hands with the object of removing the face-piece, etc. Some patients imagine that by moving their fingers, hands, or feet, at the beginning of the administration, they may afford valuable assistance to the anæsthetist by providing him with a reliable sign that consciousness is present. Unfortunately, movements originally voluntary not only tend to become automatic as consciousness becomes lost, but they may even increase to such a degree that the patient's whole body shares in the movement. (2) Uncontrollable nervous movements, also at the outset of the administration, *e.g.*, tremor of the legs, or fidgety movements of arms, hands and fingers. (3) Intoxication-movements, such as movement of the head from side to side, stamping, alternate thrusting out of the arms, etc. Such movements as these are often associated with laughter or shouting, and like the latter are due to air or to too large a percentage of oxygen in the mixture. (4) Tonic spasm. Some degree of tonic spasm is not uncommon, especially in men, but extreme conditions, such as those to which the terms opisthotonos and emprosthotonos have been applied are very rare. Sometimes the tonic spasm affects the neck muscles,

and the head gradually becomes turned to one or other side. It is difficult to say what these movements depend upon. In many cases they occur when the percentage of oxygen is rather less than usual, but this is not always so. Indeed, if the patient be a vigorous, athletic man, and too much oxygen be admitted with the nitrous oxide, excitement will arise, and marked rigidity may be occasioned. It is on such occasions as these that some degree of respiratory spasm, from contraction of thoracic and abdominal muscles, is prone to occur. In this way a primary excess of oxygen may lead to secondary cyanosis, or even to jactitation. (5) Clonic spasm. Epileptiform twitchings always indicate a diminution in the normal oxygen supply. When the diminution is but slight the clonus may be so mild that it may escape detection. The most marked clonic spasm (jactitation) is met with in children when nitrous oxide free from oxygen is rapidly inhaled. The epileptiform movements may affect all parts of the body. Whenever the anæsthetist detects any such movements commencing during the use of nitrous oxide and oxygen, he should at once increase the oxygen supply, and the movements will quickly vanish. (6) Fine tremor of arms and legs occurring during unconsciousness. This is rare ; I have only seen it in three or four cases,

and it came on when anæsthesia was fairly well established. (7) Certain peculiar tonic movements of deep anæsthesia. These are very remarkable. After a long inhalation of the gases, and when anæsthesia is well established, as may be seen from the state of the eyes, patients sometimes display peculiar movements of the arms, legs, neck, and body. The arms and legs will slowly move in a certain direction; the head will slowly turn to one side; or the whole body may begin to turn gradually in one direction or another. The movements often suggest a return of consciousness; but this is not so. When the face-piece is removed, a long and perfectly tranquil anæsthesia follows. The tonic movements differ from those referred to in (4), for they come on after relaxation of the muscular system has been produced. For want of a better term I have called the condition "secondary rigidity."

Cyanosis.—This always depends upon want of oxygen. It may either be brought about by the nitrous oxide bag becoming distended, so that little or no oxygen passes from the oxygen bag; or it may arise from respiratory spasm incidental to laughter, crying, or coughing; or the so-called "holding the breath" may take place during or immediately after the inhalation of the gases, and thus induce cyanosis. This "holding the breath" is a misnomer, for the

patient is not conscious at the time. Certain patients, especially men who are alcoholics, or inveterate smokers, are prone to muscular spasm, and when this spasm affects the chest and abdomen, temporarily arrested breathing necessarily occurs. There is no occasion for alarm in these cases, as the breathing quickly regains its normal rhythm. Cyanosis may also occur in connection with morbid states, such as enlarged tonsils, nasal polypi, post-nasal adenoid growths, bronchitis, etc. And, lastly, a faulty posture of the patient may induce it (see remarks, p. 38).

Shallow, imperceptible, or arrested breathing, associated with a good pulse and colour. This condition, which should not alarm the anæsthetist, is discussed on p. 52.

Very violent respiration at the outset of the administration may generally be corrected by requesting the patient to breathe more quietly. Should consciousness have been lost when this kind of respiration occurs, an attempt may be made to check it by administering rather less oxygen. Generally, however, the condition subsides spontaneously, to be followed by "respiratory calm" (see p. 52). In some instances, and especially when patients are very nervous, the whole body may move backwards and forwards synchronously with the exaggerated breathing.

Coughing, Crying.—Each of these is liable to be followed by asphyxial manifestations, even if the mixture contain a considerable percentage of oxygen. The former may be dependent upon faulty posture, and is to be treated by tilting the head forwards.

Retching or vomiting during the administration.—Retching at the very outset of the administration is to be treated as described on p. 40. Should retching occur towards the end of an administration, the inhalation should be discontinued. Retching movements are most likely to come on in protracted administrations, and when a considerable percentage of oxygen has been used. They are not necessarily followed by vomiting, even though food be present in the stomach. When the patient has abstained from food for several hours, both retching and vomiting are very exceptional.

Micturition.—I have only known this to occur twice in the 11 years during which I have administered nitrous oxide and oxygen, and in these cases no such accident would have taken place had the usual precautions been adopted.

Dangerous symptoms.—When sufficient oxygen is administered with nitrous oxide to prevent asphyxial complications there is every reason to believe that the anæsthesia produced is free from risk to life. A careful

study of every fatality which has been recorded in connection with the use of nitrous oxide gas shows that in most, and probably in all cases in which this agent has caused death, absence of oxygen has been primarily responsible for the occurrence. The same may also be said of those reported cases in which alarming symptoms have taken place during the administration of nitrous oxide by the customary method. The addition of oxygen to nitrous oxide renders this agent respirable, and robs it of its chief, if not its only risk. There has not yet been recorded a single fatality from nitrous oxide and oxygen, and it is difficult to understand how one could occur. Although I have now used nitrous oxide with oxygen in several thousand cases, I have only met with one case which has given me the slightest anxiety, and the symptoms in this case were only secondarily dependent upon the anæsthesia. The patient was a strongly built, nervous man, and good anæsthesia had been induced ; but on altering the position of the head in order to facilitate the removal of an upper tooth, respiration temporarily ceased and I had to pass my finger to the back of the throat to separate the tongue from the pharynx. With this exception I have not had a single case which has given me any anxiety.

Highly exceptional cases.—It is only right

to state, before concluding this chapter, that although exceptional cases are, in most instances, traceable either to some error in the preparation of the patient, or to some fault in the actual administration, they are not always referable to such causes. Thus, there are some patients who, whatever plans may be adopted in administering the mixed gas, cannot be made to pass into that tranquil state of anæsthesia which it is desired to establish. Under such unusual circumstances, the administrator must be satisfied with an anæsthesia which approaches to, or is identical with that ordinarily obtainable with nitrous oxide alone — in other words, he has to cut off the oxygen supply and terminate the case with the usual phenomena of nitrous oxide narcosis. Then there are other patients who, although they can be made to exhibit the usual signs of nitrous oxide and oxygen anæsthesia, remain such a short time under the influence of the anæsthetic that one cannot help feeling dissatisfied with the result. With regard to such cases as these, all one can say is that with nitrous oxide alone they would certainly have been even less satisfactory. Fortunately, they are extremely exceptional, so that we need not further consider them here.

CHAPTER VIII.

AFTER-EFFECTS.

A CAREFUL consideration of the circumstances under which after-effects are likely to arise is of special importance; for the one weak point, if such it may be termed, in nitrous oxide and oxygen anæsthesia, is that this anæsthesia is associated with a somewhat greater liability to unpleasant after-effects than that resulting from the administration of nitrous oxide free from oxygen.

Provided, however, that the diet of the patient has been properly regulated, and that the inhalation has not been protracted, recovery from the effects of nitrous oxide and oxygen usually takes place without the slightest discomfort. I have notes of several cases, indeed, in which the patient's condition immediately after the operation was more satisfactory than after a similar operation previously performed under nitrous oxide free from oxygen.

Thus, I have known a patient experience severe headache after an ordinary administra-

tion of pure nitrous oxide, and to suffer from no such discomfort after the inhalation of this gas with oxygen. In another of the cases of which I have notes the administration of nitrous oxide *per se* had been followed by numbness of the arms and legs, and blueness of the hands, the symptoms persisting for some time; recovery was, however, perfect after nitrous oxide and oxygen. In another case, that of a healthy-looking lad, the boy looked much better after the administration of the gas with oxygen than after an administration which had previously been conducted in the ordinary way. In a fourth case, that of a man 33 years of age, who had on a previous occasion experienced temporary loss of vision after inhaling pure nitrous oxide, no such symptoms were noted after the use of nitrous oxide and oxygen. The infrequency of distressing dreams when oxygen is used with nitrous oxide is referred to below.

Should the inhalation have been somewhat protracted, recovery will probably not be quite so satisfactory as after nitrous oxide alone. On such occasions as these, the patient may remain **dazed** and **torpid** for a few minutes, or he may complain of **sleepiness** and wish to be left undisturbed. In some cases, **giddiness, headache,** or **feelings of numbness and tingling** in the limbs may be

experienced. **Nausea,** with or without actual retching movements, may also be induced by prolonged administrations, and if there be food present in the stomach, or if blood has been swallowed, vomiting may occur.

As already mentioned (p. 36), it is very important, when a rather difficult dental operation has to be performed, and as long an anæsthesia as possible is desired, to carefully regulate the patient's diet. If this be done, inhalations lasting from two to three minutes may generally be conducted without any subsequent nausea occurring.

I find, on looking through my note books, that, of the cases in which **retching** or **vomiting** occurred after inhalation, there are eleven in which the interval between the taking of food and the administration is recorded. Of the retching cases, one was a female of 43—interval $2\frac{3}{4}$ hours; another was a female of 45—interval 3 hours; the third was a male of 23—interval 3 hours. Of the vomiting cases, one was a female of 35—interval $4\frac{1}{2}$ hours; one was a female of 13—interval $2\frac{1}{4}$ hours; one was a female of 10—interval $2\frac{1}{2}$ hours. The rest of the vomiting cases were males. Four were aged 15—intervals $2\frac{3}{4}$ hours, $2\frac{3}{4}$ hours, 2 hours, and $\frac{1}{2}$ an hour respectively; one was aged 12—interval $3\frac{1}{4}$ hours. Although these facts are very

meagre they bring into relief two interesting clinical points. One of these is that, of the cases in which vomiting occurred the average interval after food was 2½ hours. The other is that, of all subjects, boys from 10—16 are most likely to suffer from vomiting after nitrous oxide and oxygen. The lesson to be learnt from these observations is that, if we wish to avoid unpleasant after-effects, a long interval after food must be enforced, particularly in the case of young male subjects.

Transient **feelings of faintness, pallor, and feebleness of pulse** are very rare, and are in most, if not in all cases, associated with nausea or impending vomiting.

A word may be said as to the **treatment** of nausea, retching, and vomiting. Slight nausea generally subsides spontaneously after a few minutes. The patient should not be permitted to lie back in the chair, otherwise the swallowing of blood and saliva may favour vomiting. He should bend forwards, keep his eyes closed, and frequently wash out his mouth. Should the feeling of nausea be considerable, half a tumbler of water so hot that the finger can hardly be immersed in it, should be given to the patient to drink. The relief afforded by this simple measure is often remarkable. If retching movements should be present, they will usually quickly subside

after this treatment. Even if vomiting has taken place, a draught of very hot water may be given with advantage. Should pallor and faintness attend these gastric disturbances, the patient should be placed horizontally, preferably in the lateral posture.

Hysterical outbursts, crying, laughing, and similar emotional disturbances are less common than after nitrous oxide free from oxygen. The one case in which I met with a **temporary maniacal seizure** is referred to on p. 64. I have also once met with curious rigidity of a **cataleptic** character, after the administration. The patient was a female aged 26. She displayed the typical phenomena of nitrous oxide and oxygen anæsthesia; but after the operation was over she sat for a few minutes, with outstretched hands, open mouth, and closed eyes. Her colour was unaltered.

Distressing dreams are less common after nitrous oxide and oxygen than after nitrous oxide alone. The cause of this difference is difficult to define, but it is probably connected with the deeper form of anæsthesia which undoubtedly follows the inhalation of the mixture. Generally speaking, either no dream whatever is experienced, or the dream is of a pleasant description.

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